PRESENTATION TO THE
THE SIXTEENTH ANNUAL
DEPARTMENT OF DEFENSE COST ANALYSIS SYMPOSIUM

TITLE: PLANNING FOR FUTURE NAVAL FORCES AND THEIR OWNERSHIP COSTS

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HOSTED BY THE COMPTROLLER OF THE ARMY
SHERATON NATIONAL HOTEL
ARLINGTON, VIRGINIA
OCTOBER 4-7, 1981

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TECHNICAL MEMORANDUM
Serial-TM-68612
31 August 1981

Program in Logistics

Contract N00014-75-C-0729
Project NR 347 020
Office of Naval Research

Technical Memorandum are preliminary research reports for use by the University and the Office of Naval Research.

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Abstract
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Naval policy planning requires viewing the entire spectrum of annual resource allocation, over a long period. Emerging research into the trade offs between force asset levels and fund flows to support those assets is described. The method underlying the results is a feedback simulation incorporating ship and aircraft assets and their operating, maintenance, and manpower characteristics, as well as fleet ownership policies, production factors, and relative price movements. The sensitivity of force levels and their funding requirements to changes in annual budgets, in fleet characteristics, in force mix, in relative prices changes, and in production rates, is explored.

Research Supported by

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Introduction

Naval force levels and their associated budget needs have traditionally been developed through a weapon system by weapon system compilation of the best estimates of project managers, program sponsors, and budgeteers. This compilation is often overly optimistic, not so much due to project bias as to disregard of the "macro" aspects affecting naval force evolution: systematic underestimation of inflation, assumptions of "other things (i.e., other projects) held constant," benign disregard of historical trends in force characteristics, optimism on probable future budgets, and so on. History confirms that long range planning can be deficient: in 1957, an official Navy estimate was a fleet of 927 ships in year 1977. The actual 1977 fleet had 464 ships.[1] Today, a fleet in excess of 600 ships is envisioned for year 2000. Is such a fleet likely? Can it be supported?

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[1]See C. A. H. Trost and L. Wayne Arny III, "The Size of the Fleet" in Problems of Seapower as We approach the Twenty-first Century, edited by James L. George, American Enterprise Institute, Washington, D. C., 1978, p. 324

To answer such questions, a managerial technique geared toward long range, comprehensive policy analysis has been developed. It will provide an independent, macro-level way to project the major components of the Navy, as well as their associated fiscal requirements. The project is called Navy Resource Dynamics (NAVRESDYN), and is being coordinated at The George Washington University under the sponsorship of the Office of Naval Research. The primary intent of the research is to discover ways to project the "cost of ownership" of a fleet. However, the model logic is founded on the assumption that the ownership cost fund flows must be derived after understanding the stock of fleet assets that require those flows. Thus, fleet assets, and their characteristics, must be projected before obtaining their ownership costs. Additionally, the manning, operating, and maintenance policies which affect ownership costs must also be reflected.

Typical results of the preliminary research model

Under budget growth consistent with the present administration plans, and assuming "ideal" conditions (no errors in inflation, cost, or quantity estimates, etc.) the fleet in year 2000 would indeed have about 620 ships and 6100 aircraft compared with 1980's 500 ships and 5500 aircraft. It would require about 720,000 men compared with about 550,000 today. But if historical underestimation of national inflation occurs, if Congress approves supplemental budgets to partly offset the inflation effects, and if inefficiencies due to classical program and budget perturbations occur (call this the "base case") then there will be 550 ships and 5400 aircraft, less than 90 percent of the amount predicted under "ideal" conditions. A more obtainable 650,000 men would be required. If, additionally, the administration budgets, over the long term, are approved (by Congress) at "only" 99 percent of what the Defense Department asked for, then there will be under 500 ships and 5000 aircraft (and 610,000 men) in year 2000. If budgets were, in real terms, to grow three percent per year instead of seven and if manpower compensation must rise faster than expected (to retain military personnel under demographic trends), then year 2000 would see about

400 ships and 4500 aircraft, and year 2010 under 350 ships and under 2500 aircraft. Manpower demands would be about 500,000 and 360,000, respectively. Even those predictions incorporate fairly optimistic assumptions on unit cost growth, about two-thirds that of recent history. The future navy is obviously highly sensitive to small changes in funding, in relative prices, in force characteristics, and in program perturbations. This sensitivity results, because of the feedback between the ownership demands of a fleet and the available procurement dollars in a budget. Small changes in fiscal limits become large changes in procurement availability. A one percent change in funding can, as above, mean a 10 percent decrease in force size.

Included in such projections are the "historical trends"-- trends in ship and aircraft size, in complexity, in unit cost, in manpower (both at sea and ashore). These past trends are modified in attempts to reflect changes likely in the future, (thus the above "two-thirds" factor). Additionally, procurement efficiencies associated with lot size purchases of aircraft, their learning curves, and their start-up costs are reflected. Operating and maintenance cost trends are statistically derived as functions of fleet asset values. Thus, by changing characteristics of the fleet units, the force levels and their ownership costs also change. For example, compared to the year 2000 fleet of 520 ships and 5100 aircraft (the "base case") a deliberate policy to keep ship size from growing, and to keep ships from becoming more complex (i.e., to obtain a fleet of smaller, less complex units) would lead to a Navy of over 700 ships, but some important losses are associated with the shift to smaller ships. The fleet of 700 ships would cost 23 percent more to operate due to losses in fuel efficiency, and 125 percent more to operate due to losses in manning efficiency (due to less automation) causing compensation growth per man to rise significantly to obtain these manning levels. As a result, the 700 ship fleet of small ships would be about 21 percent less valuable, in terms of asset value, than the fleet of 520 larger, more complex ships.[2]

[2] The relative "effectiveness" of the two fleets is not considered here. The dispersion flexibility of the large fleet of small ships might outweigh the "value" of the 520 ship fleet.

If, as another example, one considers shifting to an all VSTOL (Vertical/Short Takeoff Landing) tactical aircraft fleet, then after 20 years there might be about 500 ships and 5100 aircraft. That VSTOL Navy would require some 650,000 men. Larger fractions of the annual budgets would go toward aircraft and ship operating costs, and toward aircraft maintenance, than would occur in the base case. The VSTOL fleet has smaller ships, overall, since large aircraft carriers become unnecessary. The average unit becomes more complex and costly due to combatants (destroyers and cruisers) being "air capable" and having aircraft maintenance capabilities. The fleet of smaller ships requires about one percent more fuel to operate, and the VSTOL aircraft fleet about five percent more. The smaller ships also mean losses in manpower efficiency, and the increased air capability requires yet some more manpower spread out over the many air capable units. The VSTOL aircraft themselves require almost 40 percent more annual maintenance funds, as a percent of the aircraft fleet value, than does the base case. The fleet of VSTOL aircraft would be about three percent less valuable, in terms of asset value than an aircraft fleet of a similar mix to today's. All these VSTOL comparisons assume the same annual "base case" budgets are expended. The VSTOL model used is preliminary, but demonstrative.

If aircraft production efficiencies occurred such that annual lot buys were doubled relative to today's, and the total buy of each model was also doubled, then the same Navy budgets would provide an aircraft fleet some 10 percent larger. This, after adjusting for the added costs of manning, operating, and maintaining the larger fleet. These are the types of policy explorations the research aims toward.

Other explorations show that sudden increases in budgets, followed by stable budgets, are less effective, in terms of fleet availability over the long term than are gradual changes in budget growth. The latter allows industry to expand efficiently. The former means losses due to attempts to suddenly obtain labor (or lay labor off), to procure material (or warehouse it). Also, costs associated with extending lead times, when demand is suddenly increased, should not be ignored.

Basic model feedback logic

The relationships between the stock of assets (e.g., ships and aircraft) and the flows of funds to operate and support those assets are based on statistical analyses relating the two. For example, historical aircraft maintenance funding requirements have been found to be a relatively constant proportion of the aircraft procurement cost in constant dollars. Fixed wing aircraft tend to require about five percent of their initial procurement cost (at the 200th aircraft procured) to maintain them annually. Rotary wing (helicopter) aircraft require about 15 percent. No strong trends in cost relative to age of the aircraft were observed--the older F-4s and A-4s did not require significantly more, or less, maintenance per procurement dollar than the newer F-14s and A-6s.

Such statistical relationships provide the parameters which flesh out the basic feedback framework of the simulation. Similar relationships have been derived for ship maintenance, for manpower versus ship generating capacity, for unit cost versus size and complexity, for manpower ashore versus the afloat-manpower-per-unit ratio, etc. The basic feedback framework, with these individual relationships incorporated, then relies on annual iterations of the following type to project future trends. Each year, starting with the present fleet, the number of units and the value of those units are compiled for ships and for aircraft. These values comprise the fleet assets. Knowing the historical relationships between such assets and their ownership needs--their manpower, maintenance, and operating requirements--allows estimating the ownership costs of the fleet in the year selected. Adjustments for policy parameters affecting ownership--such as flight hours and steaming hours, manning levels, maintenance backlogs, logistic stocks, etc.,--can be made. The ownership cost requirements are deducted from that year's Navy budget, leaving a budget residual (after some adjustments for research and development, and for other procurements) which is then available for procurement of new units to add to the fleet. Knowing historical (and also predictable) trends in unit size, complexity, and therefore in unit cost, then allows predicting the quantity and

value of new units procured and entering the fleet for future year's iterations. Lags between funding and fleet delivery (about four years for ships and two for aircraft) are incorporated into the framework. As ships last about 30 years and aircraft half that, the units leaving the active fleet are also predictable, and the net result is the following year's assets are predicted, their ownership requirements evolve, as do budget residuals for procurements once again. The procurements are dependent on ownership costs, and ownership costs on procurements and fleet characteristics. This feedback process continues through time.

Model features

Within the feedback structure, various model features and options can be applied. The allocation of procurements to ships or to aircraft (the two basic "platforms" in the Navy) are dependent on the relative numbers and on the relative age of the aircraft and ship fleets. Procurement funds available for either are then allocated toward new units or toward modernization of existing units. Modernized units obtain new characteristics (manpower needs, fuel requirements, generating capacity, etc.) which feed back into ownership costs. For example, generating capacity increases have been statistically linked to automation and therefore crew reduction.

While the basic results are in terms of "constant" (zero inflation) dollars, relative prices are nonetheless reflected. Fuel can be assumed to grow faster than the average (say GNP) inflation rate. Manpower compensation, to acknowledge increased military manpower requirements in the midst of decreasing demographics, can be adjusted. Allowing such relative price changes allows observing the shifts in budget fractions over time going to different allocations.

There is an option to retain ships and aircraft beyond their normal service lives, and the corresponding increased maintenance and renovation costs can be reflected. Manpower required ashore to support the afloat fleet is inversely related to the manpower per ship ratio--as newer ships are manned at lower levels, ashore personnel must

(apparently) grow, the inverse relationship seems to have an "elasticity" of about 20 percent: reductions at sea of 1000 men are partly offset by about a 200-man increase ashore. This is consistent with past trends but could be easily modified in the model, as can all other built in relationships.

Average ship and aircraft age, and their implications on future procurement needs, are tracked. So are fleet value, in constant dollars and in "depreciated" value. Production efficiencies associated with higher lot size buys, and production inefficiencies associated with sudden defense industry increases or decreases, are both reflected.

Regular updates of the model add new options. Upcoming directions will, for example, stress disaggregation of ships and aircraft into types, and manpower into skills. Readiness shortfalls, such as maintenance backlogs, undermanning and logistic inadequacies will be incorporated, and resource allocation schemes to optimize various fleet measures will be explored. The interplay between the Navy budget and the state of the national economy will be reflected.

<u>The model and policy analysis</u>

Earlier, simple predictions of the model output were provided. Such broad predictions are considerably useful to policy makers, who must continually struggle with decisions about resource allocations and fleet capabilities, and who must respond to inquiries from Congress, the press, the public, etc. Being able to analyze, quickly, the ramifications of going to smaller units, of shifting to a VSTOl fleet, of building up rapidly or slowly, are examples of policy planning not easily accomplished presently.

The existing planning, programming, and budgeting system (PPBS) requires weeks to make such explorations, while a broad scale feedback model of the type discussed here can provide the first order effects in minutes--hours if remodeling is needed.

The present detailed project-by-project analysis clearly cannot be replaced by such a crude parametric simulation. Particularly in the short term, say out to three or four years, the detailed approach is necessary, and for next year's budget is obviously essential. But even these near years are influenced by what will happen in the future. As one example, long term strategic balances affect the need to put aside research and development funds, which do affect next year's budget. A policy tool allowing such long range considerations then becomes useful indeed. And the effects of inaccuracies in planning, of unexpected inflation, of extraordinary cost growth, of obverse demographics, should be considered in the sensitivity analyses accomplished by planners to reflect uncertainties, and in their attempts to optimize allocations under such uncertainty. The fact that Navy force levels are much more sensitive to military compensation growth than to growth in fuel costs becomes important...that increasing unit cost associated with larger ship size and more complexity leads to some offsetting efficiencies in manpower use...that VSTOL aircraft affect fleet ownership costs in important ways not easily understood "intuitively"...all lend emphasis to the fact that <u>portions</u> of the allocation process should not be considered in isolation. The whole plan, the total macroeconomic implication, should be considered simultaneously.

The human mind is not equipped, either in capacity or consistency, to deal with many components acting and interacting simultaneously. Yet the mind can understand and model the individual relationships at play <u>within</u> a complicated framework. These individual relationships can be combined in a simulation, and the simulation placed on a computer, which <u>does</u> provide the capacity and consistency to track the entire complex process. Long range planning, and policy analysis, thus become feasible. This new direction of research into naval policy issues seems useful.